MODIS observations of the radiative effects of clouds on clear-sky reflectance

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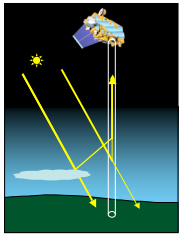
INTRODUCTION

Theoretical and observational studies (e.g., Koren et al. 2007; Wen et al. 2006, 2007) have indicated that 3-D radiative effects can cause problems in 1-D aerosol retrievals near clouds:

Reflection from clouds increases the illumination of nearby areas, causing an overestimations of aerosol optical thickness.



GOAL OF THIS STUDY

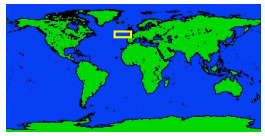
Examine whether 3-D effects are statistically important in a large dataset of 1 km-resolution MODIS data.

DATA USED

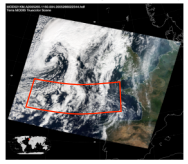
•Collection 5 MOD02, MOD06, MOD35 products
•North-East Atlantic (45°-50°N, 5°-25°W), south-west from UK
•March and September 14-29 in 2000-2007 (2X2 weeks in 8 years)
•Solar zenith angle =48°±2.5°; Viewing zenith angle < 10°

Data points included in analysis:
•Ocean surface with no glint or sea ice
•MOD35 says "confident clear", all 250 m subpixels clear
•Highest cloud top pressure nearby > 700 hPa (near low clouds)
•Nearby pixels are considered cloudy if MOD35 says "confident cloud"

Study area



Sample MODIS image over study area



CONCLUSIONS

•MODIS observations confirm that clear-sky reflectances increase near clouds.

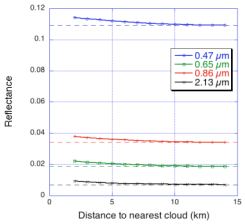
•MODIS observations show that the increase is larger : (*i*) at shorter wavelengths (*ii*) near thicker clouds (*iii*) on sunlit side of clouds

•This behavior indicates that 3-D effects are responsible for a large portion of the observed increase.

•Implication: Aerosol retrievals near clouds are influenced by 3-D radiative effects.

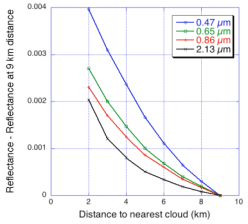
1. Dependence on wavelength

Mean reflectance for September 2000-2007



Clear-sky reflectances increase systematically near clouds.

Increase in mean reflectance
September 2000-2007



The increase is larger at shorter wavelengths. This is called "apparent bluing of aerosol in the vicinity of clouds" (Marshak et al. 2008). This is consistent with 3-D effects near clouds.

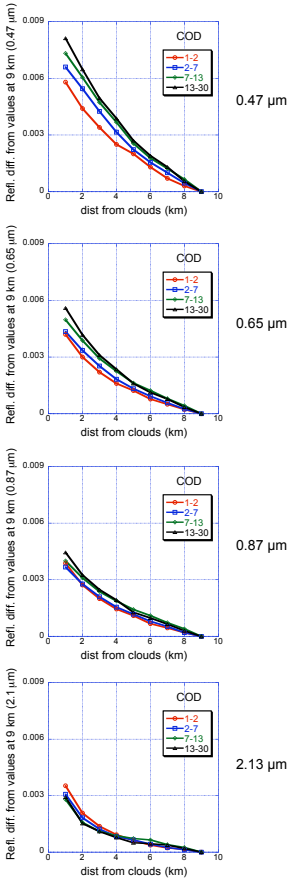
Other factors that contribute to the observed increase:

- •Larger and more aerosol particles near clouds
- •Undetected clouds
- •Instrument effects such as latency

To mitigate latency effects, only clear-sky areas with the nearest cloud in downscan direction are considered.

2. Dependence on cloud thickness

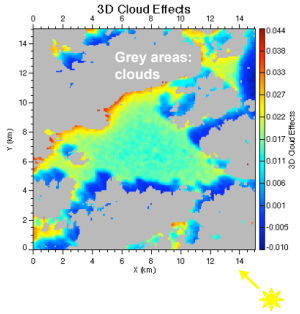
Dependence of increase near clouds
on nearby cloud optical depth (COD)



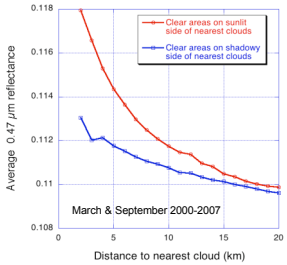
At shorter wavelengths the increase depends on the optical depth of nearby clouds, which is consistent with the presence of 3-D effects.

3. Dependence on sun-cloud geometry

3-D enhancements simulated in Wen et al. 2006,



0.47 μm reflectances observed by MODIS



In both 3-D simulations and in MODIS observations, reflectances increase more on the sunlit side of nearby clouds.

REFERENCES:

Koren, I., L. A. Remer, Y. J. Kaufman, Y. Rudich, and J. V. Martins, 2007: On the twilight zone between clouds and aerosols. *Geophys. Res. Lett.*, **34**, L08805, doi:10.1029/2007GL029253.

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